SDC

STORAGE DEVELOPER CONFERENCE

SNIA ■ SANTA CLARA, 2017

Accelerated NVMe-oF target and vhost via SPDK

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Intel

Agenda

- What is SPDK
- Accelerated NVMe-oF target/host
- Accelerated vhost target
- Summary

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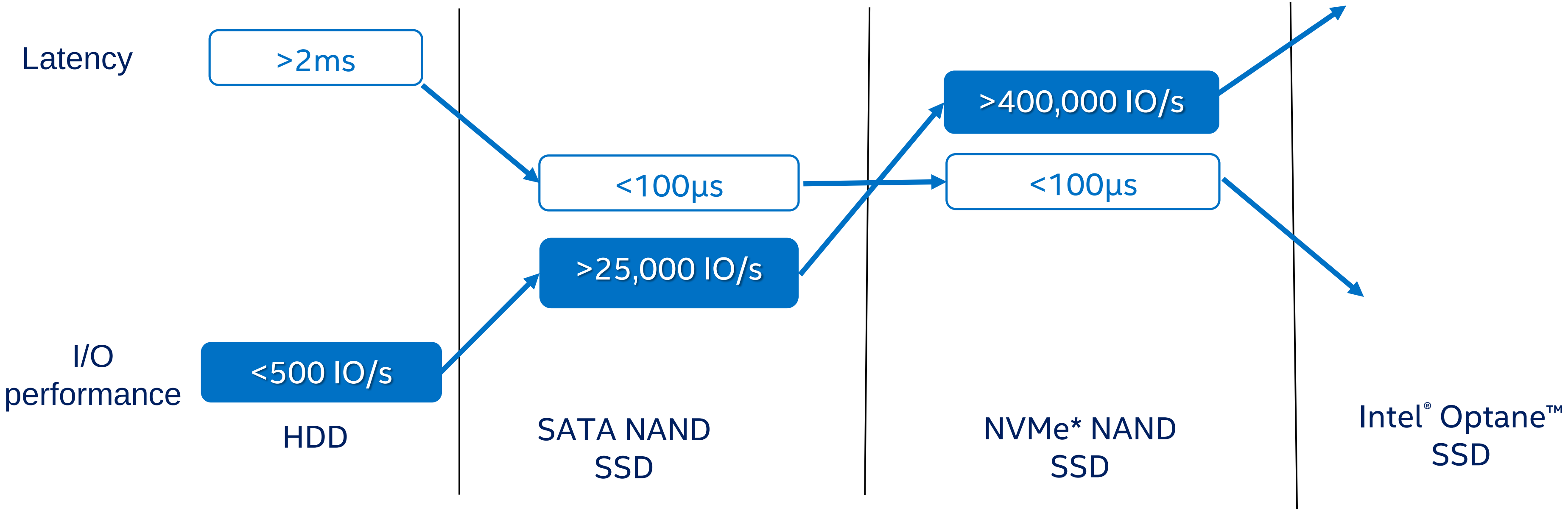
The Problem: Software is becoming the bottleneck



The Opportunity: Use Intel software ingredients to unlock the potential of new media

Storage Performance Development Kit

Intel® Platform Storage Reference Architecture

- Optimized for *Intel platform* characteristics
- Open source building blocks (BSD licensed)
- Available via github.com/spdk or spdk.io

Scalable and Efficient Software Ingredients

- User space, lockless, polled-mode components
- Up to millions of IOPS per core
- Designed for Intel Optane™ technology latencies

Benefit of using **SPDK**

SPDK
more performance from Intel CPUs, non-volatile media, and networking

Up to **10X MORE** IOPS/core for NVMe-oF* vs. Linux kernel

Up to **8X MORE** IOPS/core for NVMe vs. Linux kernel

Up to **350%** **BETTER** Tail Latency for RocksDB workloads

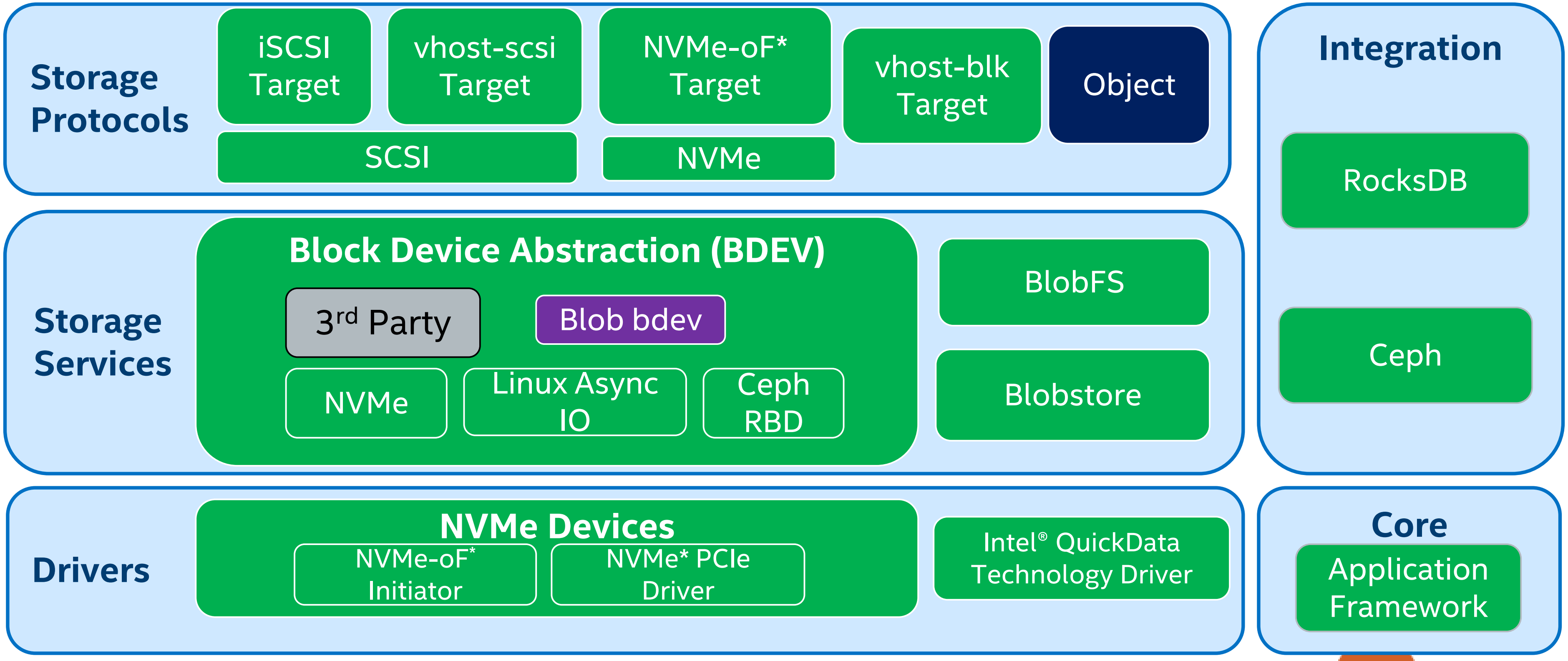
FASTER TTM/ **LESS** RESOURCES than developing components from scratch

Provides Future Proofing as NVM technologies increase in performance

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to http://www.intel.com/performance

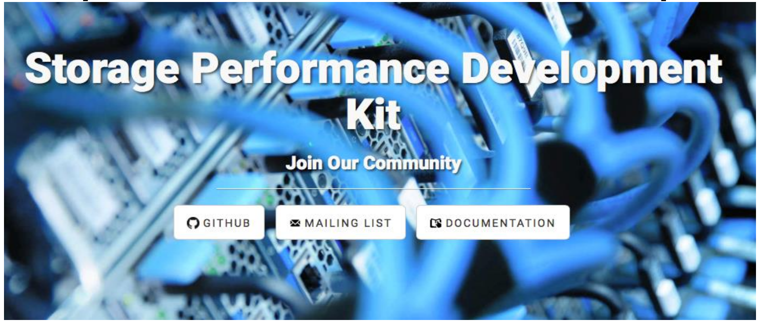
Architecture

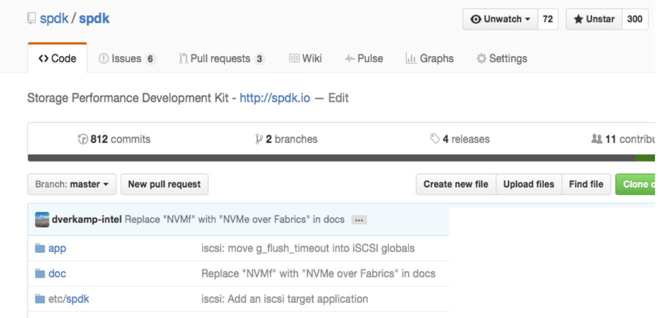
Released
Q3'17
Pathfinding



SDPK current development status

- Fully realizing new media performance requires software optimizations
- SPDK positioned to enable developers to realize this performance
- SPDK available today via http://spdk.io
- Help us build SPDK as an open source community!





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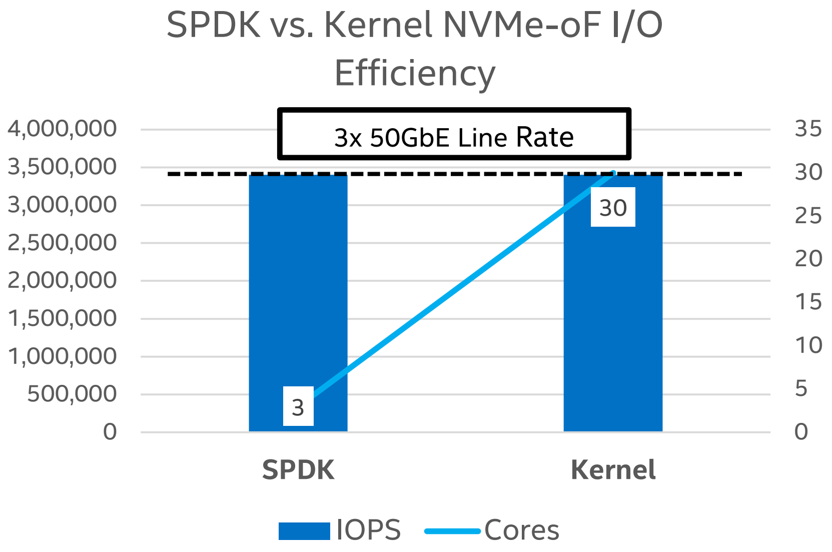
SPDK NVMe-oF Components

- **NVMe over Fabrics Target**
  - Released July 2016 (with spec)
  - **17.03 Hardening:**
    Intel test infrastructure
    Discovery simplification
    Correctness & kernel interop
  - **17.03 Performance:**
    Read latency improvement
    Scalability validation (up to 150Gbps)
    Event Framework enhancements

- **NVMe over Fabrics Host (Initiator)**
  - New component added in 16.12
  - Performance improvements in 17.03:
    Eliminate copy: now true zero-copy
    SGL (single SGL element)

NVMe-oF Target Throughput Performance comparison



NVMe* over Fabrics Target Features	Realized Benefit
Utilizes NVM Express* (NVMe) Polled Mode Driver	Reduced overhead per NVMe I/O
RDMA Queue Pair Polling	No interrupt overhead
Connections pinned to CPU cores	No synchronization overhead

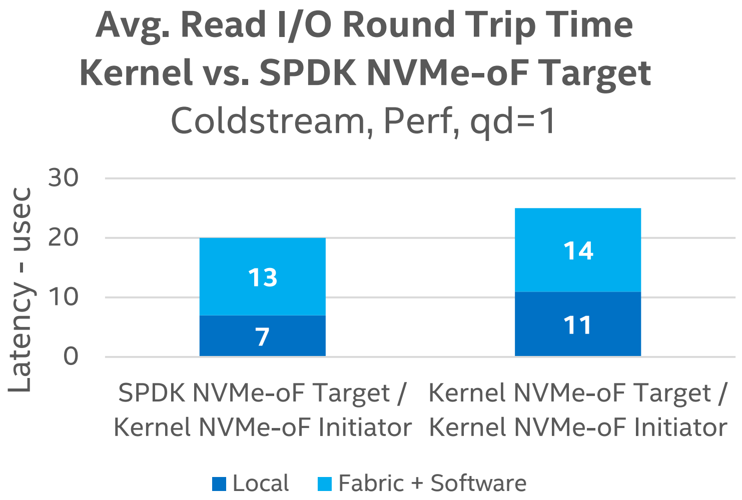
SPDK reduces NVMe over Fabrics software overhead up to 10x!

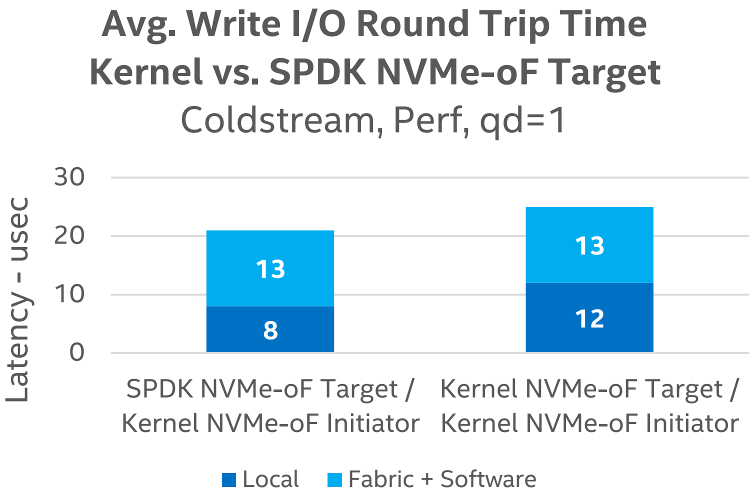
System Configuration: Target system: Supermicro SYS-2028U-TN24R4T+, 2x Intel® Xeon® E5-2699v4 (HT off), Intel® Speed Step enabled, Intel® Turbo Boost Technology enabled, 8x 8GB DDR4 2133 MT/s, 1 DIMM per channel, 12x Intel® P3700 NVMe SSD (800GB) per socket, -1H0 FW; Network: Mellanox* ConnectX-4 LX 2x25Gb RDMA, direct connection between initiators and target; Initiator OS: CentOS* Linux* 7.2, Linux kernel 4.10.0, Target OS (SPDK): Fedora 25, Linux kernel 4.9.11, Target OS (Linux kernel): Fedora 25, Linux kernel 4.9.11 Performance as measured by: fio, 4KB Random Read I/O, 2 RDMA QP per remote SSD, Numjobs=4 per SSD, Queue Depth: 32/job. SPDK commit ID: 4163626c5c

NVMe-oF Target Latency

Comparison to Linux Kernel 4.10.1 (hybrid polling enabled)

SPDK Target Eliminates ~3-5usec of protocol + driver latency per I/O



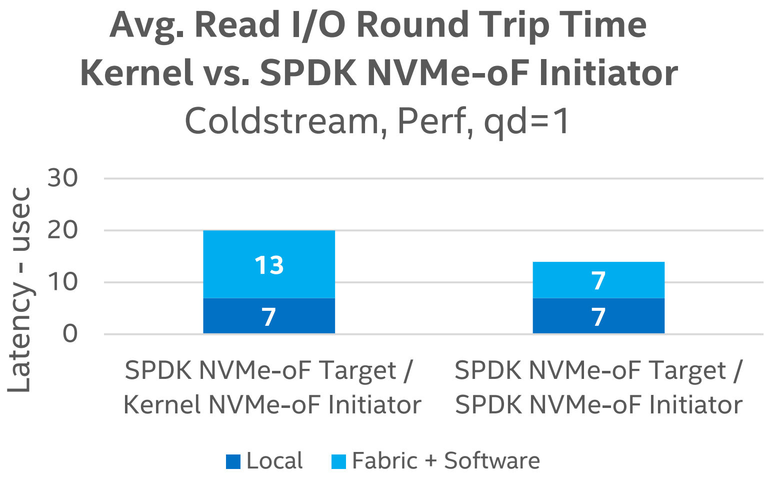


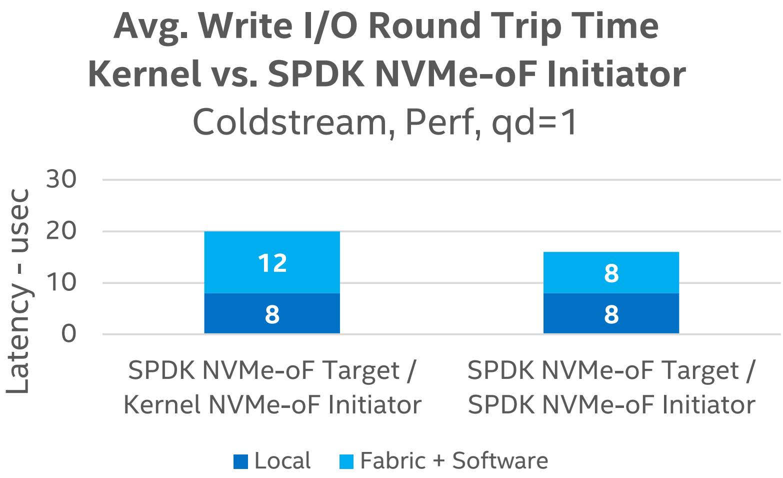
System Configuration: 2x Intel® Xeon® E5-2695v4 (HT on, Intel® Speed Step enabled, Intel® Turbo Boost Technology enabled, 64GB DDR4 Memory, 8x 8GB DDR4 2400 MT/s, Ubuntu 16.04.1, Linux kernel 4.10.1, 1x 25GbE Mellanox 2P CX-4, CX-4 FW= 14.16.1020, mlx5_core= 3.0-1 driver, 1 ColdStream, connected to socket 0, 4KB Random Read I/0 1 initiators, each initiator connected to bx NVMe-oF subsystems using 2P 25GbE Mellanox. Performance measured by Intel using SPDK perf tool, 4KB Random Read I/O, Queue Depth: 1/NVMe-oF subsystem. numjobs 1, 300 sec runtime, direct=1, norandommap=1, FIO-2.12, SPDK commit # 42eade49

NVMe-oF Host (Initiator) Latency

Comparison to Linux Kernel 4.10.1 (hybrid polling enabled)

Fabric + Software overhead: 33%-46% reduction per transaction using SPDK





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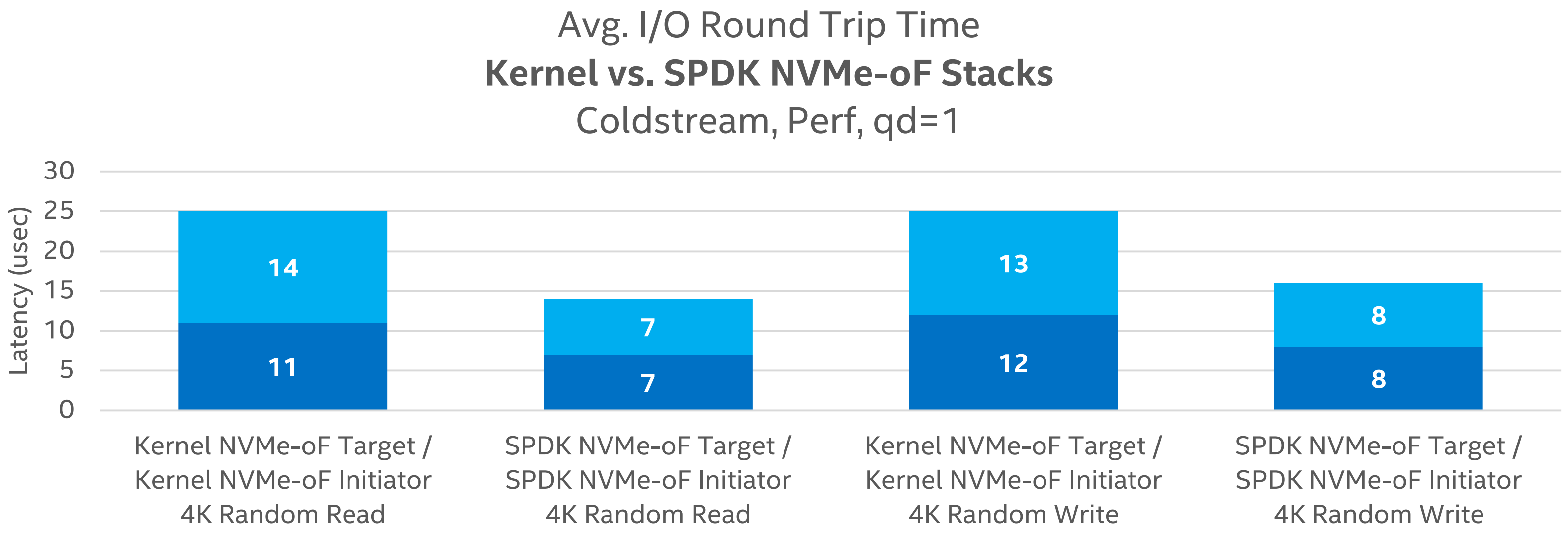
SPDK Host + Target vs. Kernel Host + Target



SPDK reduces Optane NVMe-oF latency by 44%, write latency by 32%!

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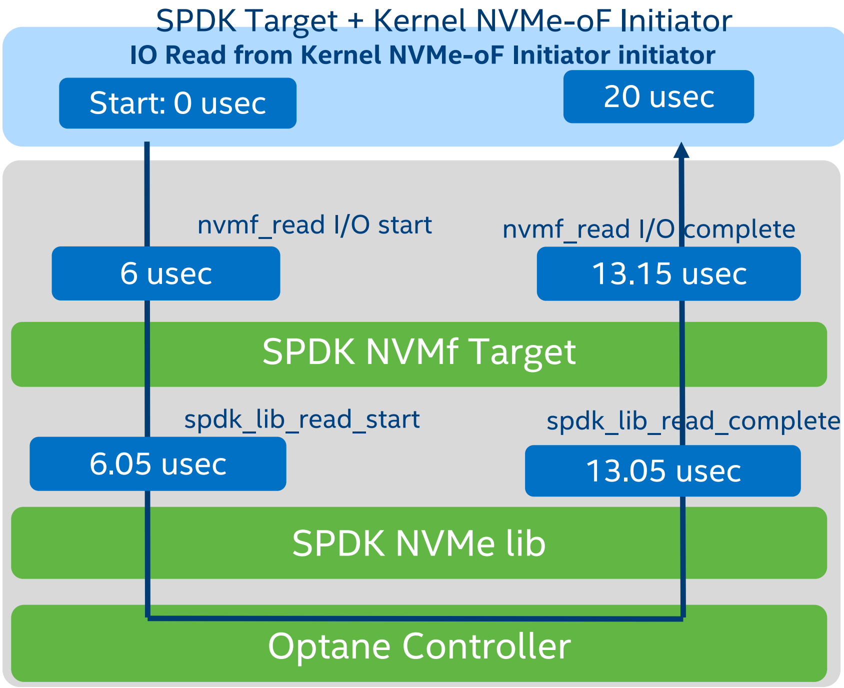
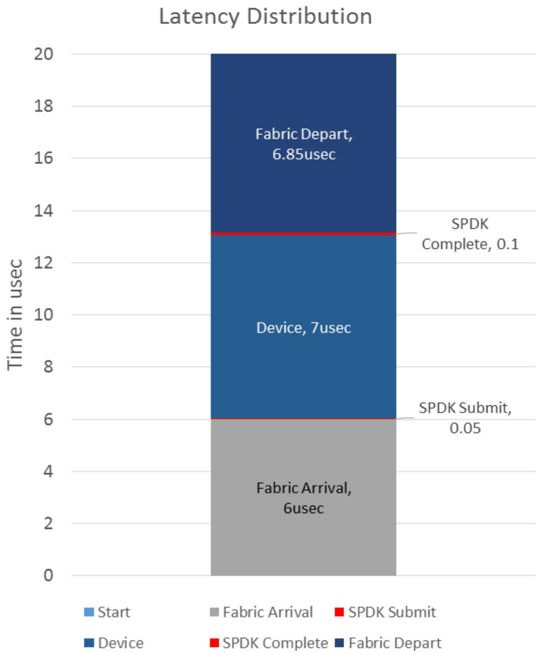
NVMe-oF IO Latency Model, 4KB Random Read (Intel Optane SSD DC P4800X)





- 20 usec round trip time measured from NVMe-oF initiator
- Out of 20usec, ~7 usec spent in NVMe controller
- 12-13 usec measured time in the fabric and kernel NVMe-oF initiator
- SPDK NVMf target adds just 100-200 nsec to fabric overhead

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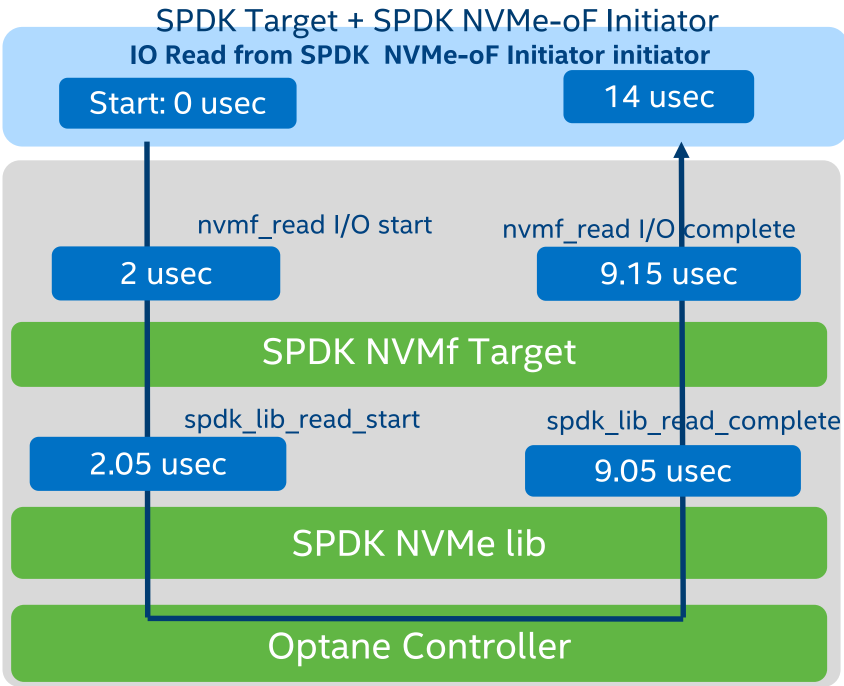

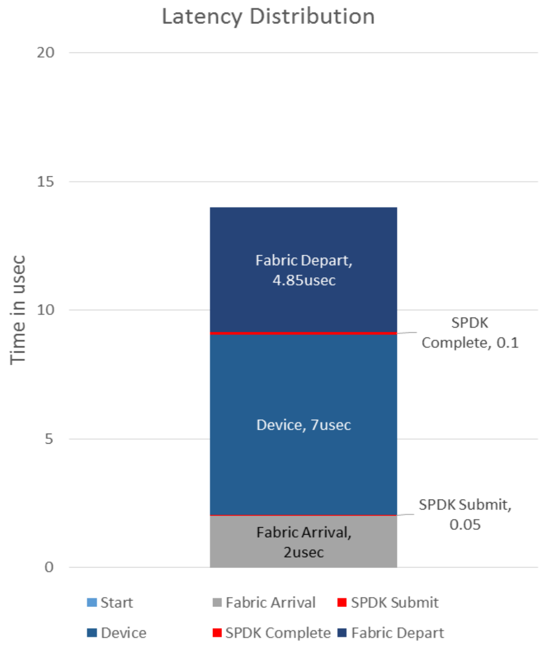

- 14 usec round trip time measured from NVMf client
- Out of 14usec, ~7 usec spent in NVMe controller
- 7 usec measured time in the fabric and SPDK NVMe-oF initiator
- SPDK NVMf target adds just 100-200 nsec to fabric overhead

Disclaimer: Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products.

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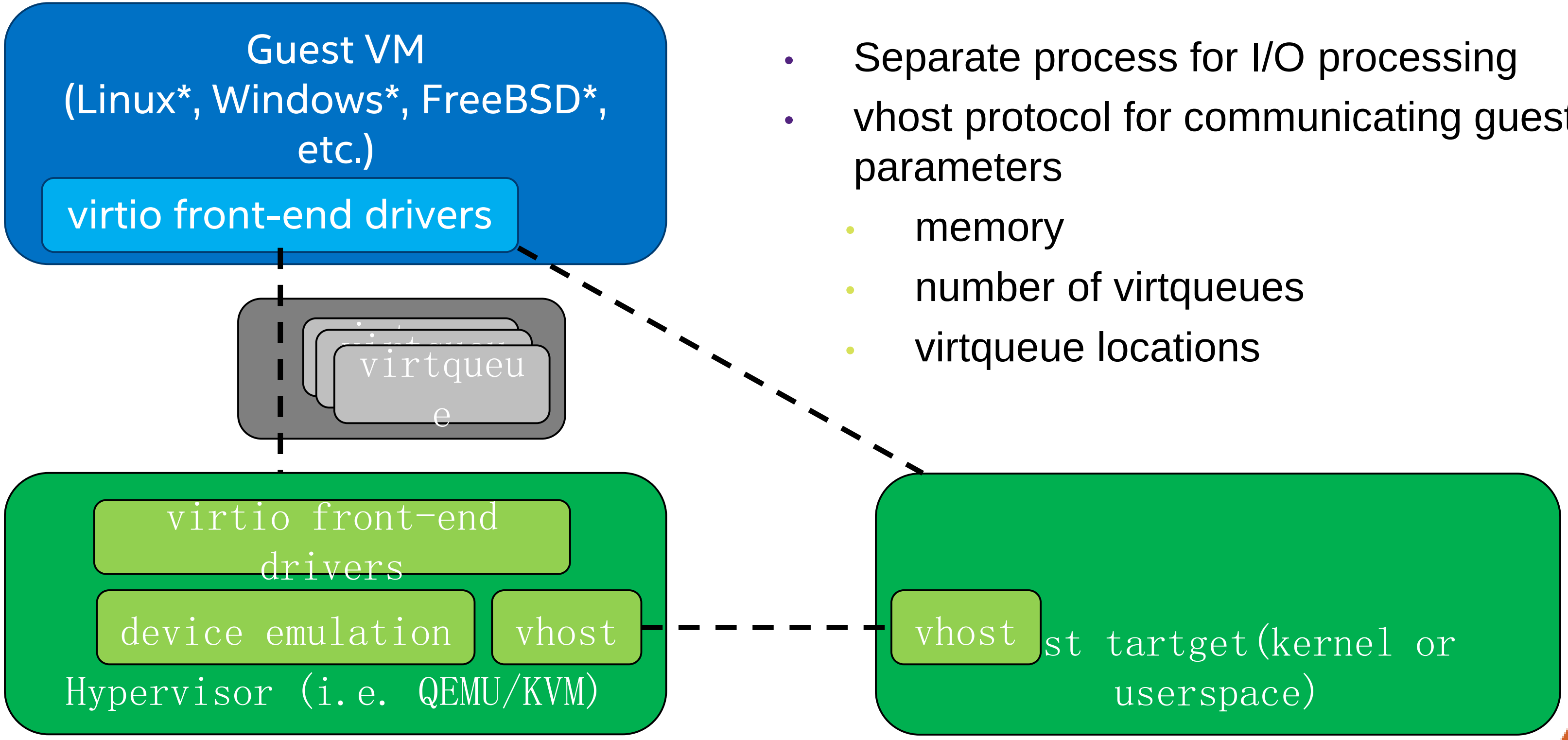
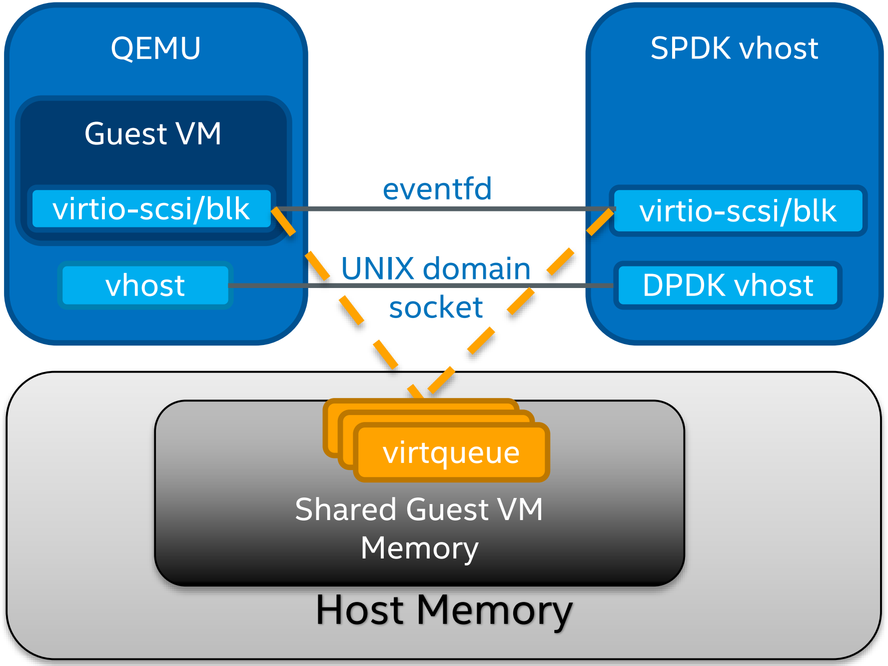
VHOST Introduction



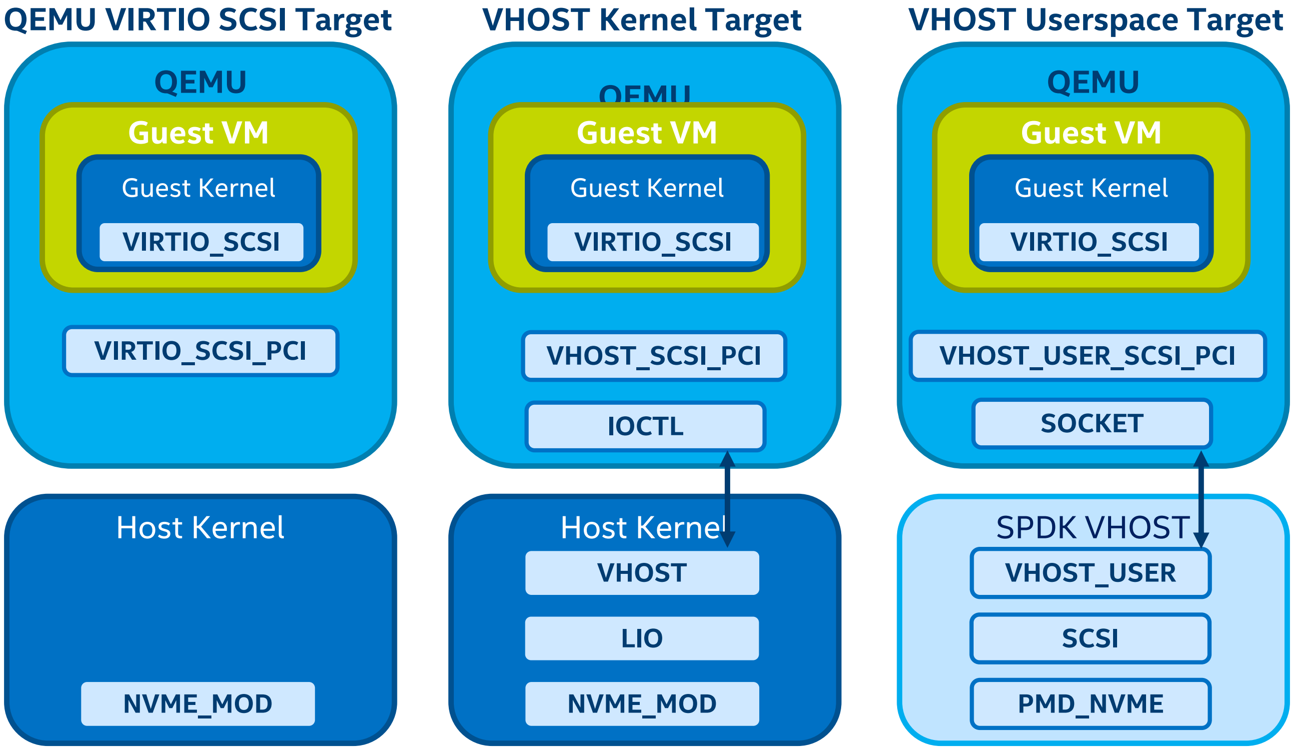
- Separate process for I/O processing
- vhost protocol for communicating guest VM parameters
  - memory
  - number of virtqueues
  - virtqueue locations

SPDK VHOST Target

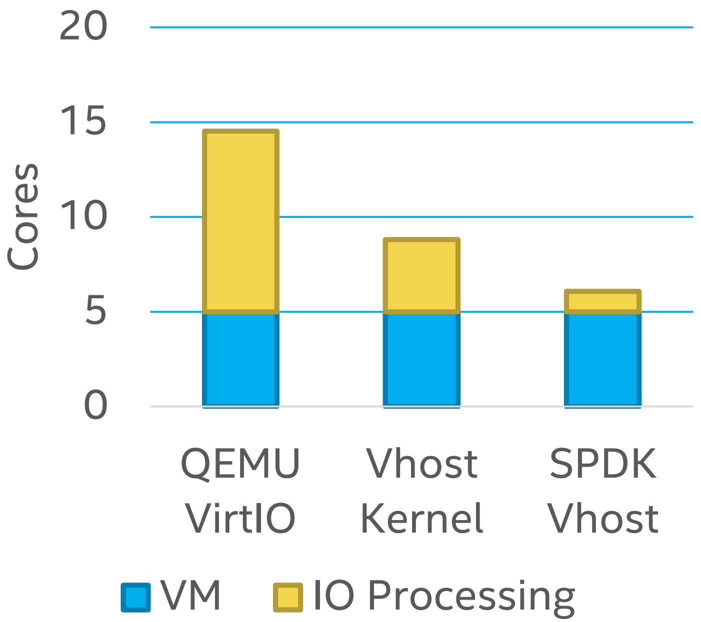


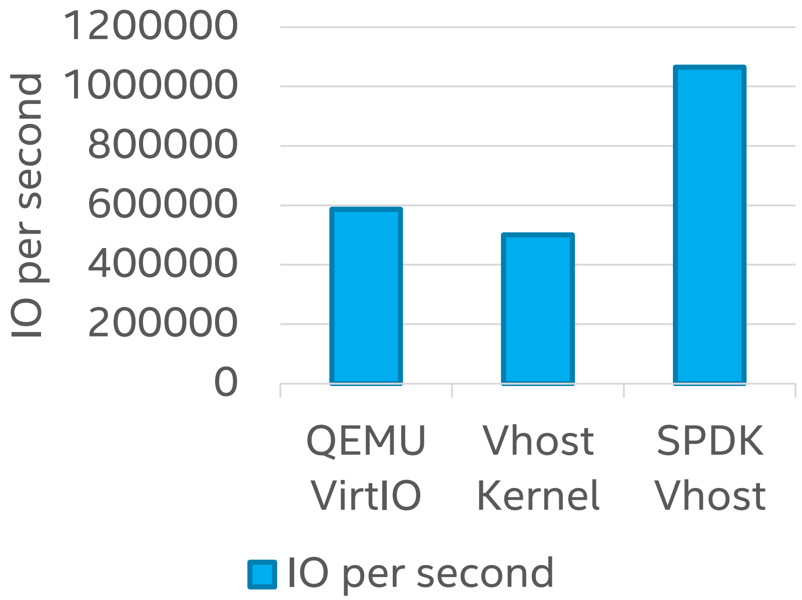
- Support virtio-scsi and virtio-blk in Guest
- QEMU sets up vhost target via UNIX domain socket memory
- Guest VM submits I/O directly to vhost target via virtqueues in shared memory, no Qemu intervention
- Completion interrupt sent using eventfd which does require system call and guest VM exit
- QEMU can pre-allocate huge pages for guest VM to enable direct DMA by vhost target

Comparison with Exist Solution



Vhost Benchmarks





configuration: 44x Intel(R) Xeon(R) CPU E5-2699 v4 @ 2.20GHz (HT off); Cores per socket: 22; 8x Samsung 8GB DDR4 @2400 12x Intel SSD DC P3700 Series 1,5T @ FW 8DV101H0 DPDK: 17.02; Host Dist/Kernel: Fedora 25/Kernel 4.8.15-300; Guest Dist/Kernel: Ubuntu 16.04/Kernel 4.4.0-59-generic, mq enabled; Fio ver: fio-2.2.10; Fio workload: blocksize=4k, iodepth=512, iodepth_batch=128, iodepth_low=256, ioengine=libaio, size=10G, ramp_time=10, group_reporting, thread, numjobs=1, direct=1, rw=randread

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Summary

- In this presentation, we introduce the two accelerated apps built from SPDK and analyze the performance:
  - Accelerated NVMe-oF target/host
  - Accelerated vhost-scsi target
- SPDK proves to be useful to accelerate storage applications equipped with NVMe based devices.
- Call for action:
  - Welcome to use SPDK and contribute into SPDK community

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Q & A